

**Remarks**

Claims 44-49, 52-54, and 57-60 are pending in the present patent application.

Claims 45 and 57 have been amended herein. New claim 61 has been added herein.

Claims 1-43, 50-51, and 55-56 have been canceled in Applicants' previously submitted responses.

As previously mentioned, new claim 61 has been added. Claim 61 is being presented at this time to more completely cover a particular aspect of Applicants' invention. Further, it is submitted that new claim 61 raises no new issues and does not require the Examiner to conduct an additional search, since the claim merely clarifies the subject matter already presented. Support for claim 61 is found, for example, at pages 11-12, paragraph [0036] and Example 6. Applicants respectfully request that the Examiner enters the above new claim.

The Office Action dated April 24, 2007 ("the Action") includes rejections under 35 U.S.C. §§ 103(a) and 112, second paragraph. In view of the following remarks, reconsideration and withdrawal of the rejections are requested respectfully.

**Summary of the Invention**

Applicants' claimed invention defines a process for cleaning a substance from a reactor surface that includes, *inter alia*, the steps of:

- (1) providing a reactor containing the reactor surface, wherein the substance has a dielectric constant of 4.1 or greater and is at least one member of the group consisting of a transition metal oxide, a transition metal silicate, a Group 13 metal oxide, a Group 13 metal silicate, a nitrogen containing transition metal oxide, a nitrogen containing transition metal silicate, or a laminate comprising at least one layer of the group consisting of a transition metal oxide, a transition metal silicate, a Group 13 metal oxide, a Group 13 metal silicate, a nitrogen containing Group 13 metal oxide, a nitrogen containing Group 13 metal silicate, a nitrogen containing transition metal oxide, and a nitrogen containing transition metal silicate;
- (2) introducing a reactive agent into the reaction chamber wherein reactive agent comprises at least one fluorine-containing compound and at least one other

compound comprising  $\text{BCl}_3$  **wherein the amount of fluorine-containing compound is less than 50% by volume of an amount of the at least one other compound;**

- (3) exposing the reactive agent to one or more energy sources sufficient to react the substance with the reactive agent and form a volatile product; and
- (4) removing the volatile product from the reaction chamber (see, e.g., claim 44).

In certain embodiments, such as Applicants' claim 61, the at least one fluorine-containing compound comprises  $\text{NF}_3$ .

High-k substances such as, for example,  $\text{Al}_2\text{O}_3$ ,  $\text{Al}_2\text{Si}_w\text{O}_z$ ,  $\text{HfO}_2$ ,  $\text{ZrO}_2$ ,  $\text{HfSi}_x\text{O}_y$ , and  $\text{ZrSi}_x\text{O}_y$ , are very stable and are resistive against most etching reactions (see Applicants' specification at ¶¶ 3 and 6). As a result, very powerful plasma conditions have been used in the prior art to remove such substances in the manufacture of flat panel display devices with little success (see Applicants' specification at ¶ 7). Such methods, however, are not suitable for cleaning depositions on grounded CVD chamber surfaces (id.). Thus, prior art methods for cleaning high-k substances from CVD chambers have been limited to mechanical means (see Applicants' specification at ¶ 11).

Fluorine-containing plasma-based processes (*i.e.*, dry cleaning) are typically used to remove residues of silicon compounds and tungsten from the interior surfaces of CVD chambers. Fluorine-based chemistry, however, may be ineffective to remove high-k substances such as, for example,  $\text{Al}_2\text{O}_3$ ,  $\text{HfO}_2$ ,  $\text{ZrO}_2$ ,  $\text{HfSi}_x\text{O}_y$ , and  $\text{ZrSi}_x\text{O}_y$  because the fluoride product is nonvolatile (see Applicants' specification at ¶ 12).

Comparative Example 1 illustrates that with respect to some of the high-k substances recited in Applicants' claims ( $\text{Al}_2\text{O}_3$ ,  $\text{HfO}_2$ , and  $\text{ZrO}_2$ ) it was surprisingly discovered the chlorides of these metals ( $\text{AlCl}_3$ ,  $\text{HfCl}_4$ , and  $\text{ZrCl}_4$ ) were **more volatile** than the corresponding fluorides (see Applicants' specification at Examples 1-3, Comparative Example 1, and Tables 24-28 and 31). Despite the fact that the fluorides of transition metals such as, for example,

Hf<sub>4</sub> and ZrF<sub>4</sub>, are less volatile than the corresponding chlorides, Applicants have surprisingly discovered that by adding a minor amount (e.g., less than 50% by volume) of fluorine-containing compound to at least one other compound, such as the chlorine-containing reactive agent BCl<sub>3</sub>, significantly enhanced the etch rate of these high-k metal oxides thereby allowing the removal of such compounds in a more energy efficient manner (see Applicants' specification at ¶ 36). Further, it was surprisingly discovered in Example 6 that an addition of a minor amount of NF<sub>3</sub> to at least one other compound, such as the chlorine-containing reactive agent BCl<sub>3</sub>, either enhanced -or in the case of ZrO<sub>2</sub>- enabled the etch rate of the high-k materials (see Applicants' specification at ¶¶ 81-83 and Figures 7a-7c). Notably, this synergistic effect was not observed when higher amounts of NF<sub>3</sub> was added. (see Applicants' specification at Figures 7a-7c)

#### Discussion of the Rejections Under 35 U.S.C. § 103

Claim 44 and claims 45-59, 52-54 and 57-60 have been rejected under §103(a) as allegedly being obvious by Japanese Published Application JP 2003-203,907 to Masayuki ("Masayuki"). Applicants respectfully request that the obviousness rejection of the claims be removed because the Examiner has failed to establish a *prima facie* case of obviousness.

To establish a *prima facie* case of obviousness, it is fundamental that the prior art must teach or suggest all the claim limitations. MPEP § 2143. As previously discussed, Applicants' claimed invention defines a process for cleaning a substance from a reactor surface by reacting the substance with a **reactive agent**. As detailed above, the substance is specifically recited as being "has a dielectric constant of 4.1 or greater and is at least one member of the group consisting of a transition metal oxide, a transition metal silicate, a Group 13 metal oxide, a Group 13 metal silicate, a nitrogen containing transition metal oxide, a nitrogen containing transition metal silicate, or a laminate comprising at least one layer of

the group consisting of a transition metal oxide, a transition metal silicate, a Group 13 metal oxide, a Group 13 metal silicate, a nitrogen containing Group 13 metal oxide, a nitrogen containing Group 13 metal silicate, a nitrogen containing transition metal oxide, a nitrogen containing transition metal silicate.” The **reactive agent** is specifically recited as comprising “at least one fluorine-containing compound and at least one other compound comprising  $\text{BCl}_3$  **wherein the amount of fluorine-containing compound is less than 50% by volume of an amount of the at least one other compound.**” (emphasis added).

Masayuki, in contrast, is directed to a process for cleaning a CVD reaction chamber that uses a chlorine cleaning gas to remove Ti oxide, Zr oxide, and Hf oxide deposits from inside the chamber. As such, Masayuki does not disclose the reactive agent recited by Applicants’ claimed invention, *i.e.*, at least one fluorine-containing compound and at least one other compound comprising  $\text{BCl}_3$  wherein the amount of fluorine-containing compound is less than 50% by volume of an amount of the at least one other compound. Thus, Masayuki patent does not teach each and every element of Applicants’ claimed invention. Further, Masayuki teaches away from including fluorine in the reactive agent through, for example, some of the following statements: “etching … metal oxide film…by contacting the chlorine-based gas which contains a chlorine atom without including a fluorine atom”; “the resultant generated when not the gas of the fluorine system of  $\text{NF}_3$  grade but the gas of a chlorine system is contacted to Ti oxide deposited in the reaction chamber…”; and “it is more desirable not to include a fluorine in [the] cleaning gas, in order to avoid an adverse effect.” (see Masayuki at ¶¶ 11, 14, and 25).

In addition to requiring that the prior art must teach or suggest all the claim limitations, a *prima facie* case of obviousness requires “there must be some teaching, suggestion or motivation in the prior art to make the specific combination that was made by the applicant.” *In re Dance*, 160 F.3d 1339, 1343, 48 USPQ2d 1635, 1637 (Fed. Cir. 1998). “In other words,

the examiner must show reasons that the skilled artisan, confronted with the same problem as the inventor and with no knowledge of the claimed invention, would select the elements from the cited prior art references for combination in the manner claimed." *In re Rouffet*, 149 F.3d 1350, 1357, 47 USPQ2d 1453, 1458 (Fed. Cir. 1998). There is no evidence of record indicating that those of ordinary skill in the art at the time of the present invention would have been motivated to modify the Masayuki reference to provide the missing recitation, e.g., "at least one fluorine-containing compound and at least one other compound comprising  $BCl_3$  wherein the amount of fluorine-containing compound is less than 50% by volume of an amount of the at least one other compound". This is particularly unlikely because Masayuki appears to teach away from the inclusion of a fluorine-containing compound in the cleaning gas. Accordingly, reconsideration and withdrawal of the rejection under 35 U.S.C. § 103(a) in view of Masayuki is requested respectfully.

**Discussion of the Rejection Under 35 U.S.C. § 112, Second Paragraph**

Claims 45 and 57 have been rejected under 35 U.S.C. § 112, second paragraph, as allegedly being indefinite for failing to particularly point out and distinctly claim the subject matter that Applicants regard as the invention. The Action also alleged that claims 45 and 57 conflict in scope with claim 44 from which they depend. Although Applicants disagree respectfully that claims 45 and 57 are indefinite, Applicants submit that this rejection is moot in view of the amendments made herein.

**Conclusion**

Applicants believe that the foregoing constitutes a complete and full response to the Action of record. Applicants respectfully submit that this application is now in condition for allowance. Accordingly, an indication of allowability and an early Notice of Allowance are respectfully requested.

The Commissioner is hereby authorized to charge the fee required and any additional fees that may be needed to Deposit Account No. 01-0493 in the name of Air Products and Chemicals, Inc.

Respectfully submitted,



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attachments: Petition for a Two Month Extension of Time

PTO Form SB/22